

WHAT IS CLAIMED IS:

1. A method for making at least one electrolytic capacitor, integrated with a substrate adapted to carry integrated circuit components, wherein said substrate is coated with at least one sequence of each of the following layers:

a vacuum deposited film having a high specific surface area, which is selected from the group consisting of valve metals and mixtures of valve metals with valve metal oxides;

superimposed on said film having a high specific surface area, at least one dielectric film comprising a substance selected from the group consisting of valve metal oxides, their complex oxides with at least one rare earth metal and their complex oxides with at least one alkaline earth metal; and

a solid electrolyte film superimposed on said at least one film.

2. A method according to claim 1, which comprises at least one of the following features:

forming said film having a high specific surface area by placing the substrate in an inert atmosphere having a pressure in the range between about 10^{-3} torr and about 10^{-2} torr, and evaporating at least one valve metal onto said substrate under said inert atmosphere, thereby imparting a surface structure to the substrate;

forming said at least one dielectric film by a procedure selected from:

plasma anodic oxidation;

evaporating at least one valve metal onto said vacuum deposited film having a high specific surface area, in an oxidizing atmosphere,

evaporating said oxide directly onto said vacuum deposited film having a high specific surface area, and

thermally oxidizing said vacuum deposited film having a high specific surface area;
forming an additional metal oxide film by electrolytic anodization between said at least one dielectric film and said solid electrolyte film;
vacuum deposition of at least one metal film onto said solid electrolyte film.

3. A method according to claim 2, which comprises additionally at least one of the following features:

independently selecting each of said valve metals from the group consisting of tantalum and aluminum;

selecting the same metal for each of said valve metals;

forming said at least one film as a discontinuous layer, on said vacuum deposited film having a high specific surface area;

utilizing as said substrate one which is adapted to be used as a printed circuit board substrate;

utilizing as said inert atmosphere one which includes nitrogen;

utilizing as said inert atmosphere one which is anhydrous;

introducing oxygen into said inert atmosphere prior to said evaporating of said at least one valve metal;

heating said substrate to between about 350°C and about 550°C during said evaporating of said at least one valve metal;

vacuum depositing said film having a high specific surface area under such conditions that it forms a cauliflower-like morphology.

4. A method according to claim 1, which comprises at least one of the following features:

forming said at least one dielectric film by a procedure selected from vacuum deposition and plasma anodic oxidation;

forming said solid electrolyte film by vacuum deposition;

carrying out all operations at a temperature below about 250°C.

5. A method according to claim 1, wherein said film having a high specific surface area is vacuum deposited under such conditions that it has a fractal surficial structure which includes both valve metal and an oxide thereof.

6. A method according to claim 5, wherein said valve metal is aluminum.

7. A method according to claim 1, wherein said film having a high specific surface area is vacuum deposited under such conditions that it has a columnar structure.

8. A method according to claim 1, wherein said at least one dielectric film is at least one valve metal oxide film applied by electrolytic anodization, of at least one valve metal present in said vacuum deposited film having a high specific surface area.

9. A method for making an integrated electrolytic capacitor, wherein a substrate is coated with each of the following layers:

a vacuum deposited film of high specific surface area, which has a fractal surficial structure including both a valve metal and an oxide thereof, provided that where said valve

metal is aluminum and said film having a high specific surface area contains no more than about 30.3% of the total aluminum as aluminum oxide;

superimposed on said film having a high specific surface area, at least one film of an oxide applied by electrolytic anodization, of at least one valve metal present in said vacuum deposited film having a high specific surface area; and

a solid electrolyte film superimposed on said at least one film.

10. An integrated electrolytic capacitor which comprises at least one sequence of each of the following layers coated on a substrate adapted to carry integrated circuit components:

a non-anodized vacuum deposited film having a high specific surface area, which is selected from the group consisting of valve metals and mixtures of valve metals with valve metal oxides;

superimposed on said film having a high specific surface area, at least one dielectric film comprising a substance selected from the group consisting of valve metal oxides, their complex oxides with at least one rare earth metal and their complex oxides with at least one alkaline earth metal;

an optional additional metal oxide film formed by electrolytic anodization and superimposed on said at least one film; and

a solid electrolyte film superimposed on said at least one film, or additionally or alternatively on said additional metal oxide film if present.

11. A capacitor according to claim 10, wherein at least one of the following features is present:

it comprises also a vacuum deposited metal film superimposed on said solid electrolyte film;

said film having a high specific surface area possesses a structure selected from the group consisting of fractal and columnar structures;

said at least one dielectric film is selected from a vacuum deposited film and a plasma anodic oxidized film;

said solid electrolyte film is a vacuum deposited film;

each of said metals, and the metal of said additional metal oxide if present, is independently selected from tantalum and aluminum;

said substrate is adapted to be used as a printed circuit board substrate.

12. A capacitor according to claim 11, wherein each of said metals, and the metal of said additional metal oxide if present, is identical.

13. A capacitor according to claim 12, wherein said metal is aluminum.

14. An integrated electrolytic capacitor, comprising a substrate coated with each of the following layers:

a vacuum deposited film of high specific surface area, which has a fractal surficial structure including both a valve metal and an oxide thereof;

superimposed on said film having a high specific surface area, at least one film of an oxide applied by electrolytic anodization, of at least one valve metal present in said vacuum deposited film having a high specific surface area; and

a solid electrolyte film superimposed on said at least one film;

provided that said valve metal is aluminum and said film having a high specific surface area contains no more than about 30.3% of the total aluminum as aluminum oxide.

15. An integrated electrolytic capacitor, which comprises an electrically conductive substrate; a dielectric coating, on the surface of said substrate, having a bimodal morphology, in that the coating includes both a non-electrolytically formed valve metal oxide layer and an electrolytically formed valve metal oxide layer, wherein the non-electrolytically formed layer is homogeneous and the electrolytically formed layer is increasingly porous towards its outer surface; a solid electrolyte film superimposed on said dielectric coating; and an optional vacuum deposited metal film superimposed on said solid electrolyte film; provided that at least one of the following conditions is fulfilled:

said non-electrolytically formed valve metal oxide layer comprises at least one substance selected from the group consisting of valve metal oxides, their complex oxides with at least one rare earth metal and their complex oxides with at least one alkaline earth metal; or (and)

each valve metal is selected independently from the group consisting of tantalum and aluminum.

16. A capacitor according to claim 10, wherein said substrate is a planar metallic substrate, said solid electrolyte film being connected electrically and mechanically to a metallic member parallel to and substantially coextensive with said substrate, and said capacitor containing if desired injected insulating material in any internal or external voids, if present.

17. A capacitor according to claim 10, wherein said vacuum deposited film having a high specific surface area consists of sequentially deposited first and second sub-films, namely, a first relatively thick film selected from the group consisting of aluminum and mixtures of aluminum with aluminum oxide, and a second relatively thin film selected from the group consisting of valve metals and mixtures of valve metals with valve metal oxides wherein the valve metal is other than aluminum and the valve metal oxides exclude aluminum oxide.

18. A capacitor according to claim 14, wherein said substrate is adapted to be used as a printed circuit board substrate.

19. A capacitor according to claim 15, wherein said substrate is adapted to be used as a printed circuit board substrate.

20. A capacitor according claim 14, wherein said substrate is a planar metallic substrate, said solid electrolyte film being connected electrically and mechanically to a metallic member parallel to and substantially coextensive with said substrate, and said capacitor containing if desired injected insulating material in any internal or external voids, if present.

21. A capacitor according claim 15, wherein said substrate is a planar metallic substrate, said solid electrolyte film being connected electrically and mechanically to a metallic member parallel to and substantially coextensive with said substrate, and said capacitor containing if desired injected insulating material in any internal or external voids, if present.

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22. A method according to claim 9, wherein all operations are carried out at a temperature below about 250°C.